Geo-Environmental Impact of Quarrying Activities on Soil Qualities in Ikpeshi, Akoko-Edo, Edo State, Nigeria

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Abstract- ***This study was conducted to investigate the geo-environmental impact of quarrying activities on soil in Ikpeshi, Akoko-Edo, Edo State, Nigeria. The study was carried out by collection of soil samples within and around the quarrying site for physico-chemical and heavy metals analysis in the laboratory. Soil index was used to evaluate the presence heavy metals in the soils, the study reveals that the soil around the quarries has a moderate to considerable contamination levels of heavy metals. The concentration of heavy metals of the soil in the study area shows that the heavy metals exceeded the World Health Organization (WHO) standard, indicating a high level of soil contamination in the study area due to the quarrying activities. The geo-accumulation index for heavy metals in the soils shows that the soils in the study area around the factories and quarries has an unpolluted to moderately polluted geo-accumulation index, while those around the streams and hand-dug wells has an unpolluted geo-accumulation index, soils around the factories, quarries and hand-dug well has an unpolluted geo-accumulation index for manganese, while those around the streams has an unpolluted to moderately polluted geo-accumulation index. The soils in the study area have an unpolluted geo-accumulation index for zinc, copper, lead, and unpolluted to moderately polluted geo-accumulation index for cadmium and nickel. The soils around the factories, quarries and hand-dug well has an unpolluted geo-accumulation index for arsenic, while those around the streams has an unpolluted to moderately polluted geo-accumulation index. The degree of contamination index of the soils in the study area shows that the soils have a low degree of contamination index. There is need for constant monitoring of the contamination level of the soil within and around the quarries.***

Indexed Terms- ***Heavy metals, physico-chemical, soil, quarry***

I. INTRODUCTION

Mining activities usually include exploration and prospecting stage, discovery stage, development stage, production stage, and reclamation stage, and all these various stages has its impact on the environment. During mining and post mining activities, the rocks hosting these minerals usually contain trace elements which eventually find their way into the environment and are of great environmental hazards [1]. Mining activities such as drilling and blasting operations, haulage of mined materials and other mine machineries usually release emission and their interaction with the soils in the area can impact the quality of the soils within and around the mining environment, resulting in environmental pollution and degradation [2]. Mining has lots economic impacts but the associating environmental impacts such as land degradation, heavy metal contamination of the soil, air pollution and surface water and groundwater pollution and health challenges are of great concern if not properly handled [3].

The mining activities in the study area pose major threat to the environment, which necessitated this research in investigation geo-environmental impact of quarrying activities on soil and air quality of the study area. The aim of the study is to evaluate the physico-chemical quality properties of the soil samples in the study area in estimating the degree of impact of quarrying on the study area.

II. THE STUDY AREA

The study area lies within latitude N7°06' and N7°11'and longitude E006°08' and E006°15', in South Western Nigeria. Geologically, the area falls within the Southwestern Pre-Cambrian basement complex of Nigeria, consisting of crystalline basement complex rocks and meta-sediments (schists, calc-silicate rock, quartzites, marble, meta-conglomerates, dolomitic-marbles) (figure 1), with granitic intruding the most easterly schist belts [4]. The schist been foliated in NW-SE direction and some others N-S. Calc-silicate rocks, dolomite and marble are been mined in the study area and are of great economic importance.

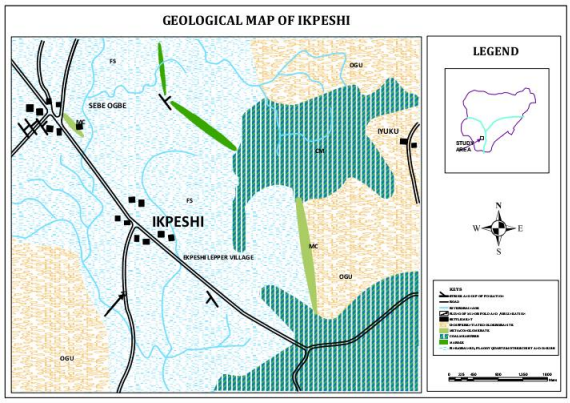

Fig. 1: Geology map of Nigeria [5]

III. METHODOLOGY

- Soil Analysis

Soil samples were obtained from the quarries and from its neighboring environments at random fashion according to simple random standard sampling procedure and the uneven location of the quarries. The soil samples were taken to the laboratory for analysis using volumetric apparatus and Atomic Absorption Spectrophotometer.100 cm^3 of mixed sample was transferred into a 125 cm^3 conical flask. 5 cm^3 of conc. HNO_3 was added with few boiling chips. It was brought to a slow boiling and evaporated on a hot plate to the lowest volume possible (about 10 to 20 cm^3) before precipitation occurred. The heating and adding of concentrated HNO_3 was continued as necessary until digestion was completed as shown by a light coloured, clear solution. The flask walls were washed down with water and then filtered. The filtrate was transferred into a 100 cm^3 volumetric flask with two 5 cm^3 portions of water which was added to the volumetric flask. This was diluted to mark and mixed thoroughly. The solution was taken for required metal determinations by Atomic Absorption Spectrophotometer.

IV. RESULTS AND DISCUSSION

The table I and 2 shows the statistical physico-chemical and heavy metals concentration of soils in the study area respectively.

Table I: Statistical Physico-chemical Analysis of Soil in the Study Area

Parameters	Mean	StD	Range
pH	7.6	0.58	2.10
EC µS/cm	350.20	115.81	411.00
Na meq/100g	1.02	0.33	1.30
K meq/100g	0.56	0.21	0.72
*Ca*meq/100g	2.30	0.48	1.82
Mg meq/100g	0.80	0.31	1.37
Cl mg/kg	375.00	125.74	746.00
P mg/kg	3.39	0.78	3.40
NO_2 *mg/kg*	0.06	0.02	0.06
NO_3 *mg/kg*	1.64	0.52	2.20
SO_4 *mg/kg*	1.15	0.33	1.41

StD – Standard deviation

Table 2: Statistical Heavy Metals in the Soil of the Study Area

Parameters	Mean	StD	Range	WHO
Fe mg/kg	62.33	9.35	25.60	50.0
Mn mg/kg	29.85	5.36	14.30	2.0
Cu mg/kg	30.57	5.19	15.00	0.1
Zn mg/kg	65.42	10.82	28.30	0.3
Pb mg/kg	4.18	0.80	2.06	0.1
Cd mg/kg	1.65	0.39	1.05	0.003
As mg/kg	0.48	0.09	0.26	0.02
Ni mg/kg	0.91	0.17	0.44	0.05

StD – Standard deviation

The concentration of heavy metals of the soil in the study area shows that the heavy metals (Table 2) exceeded the World Health Organization (WHO) standard, indicating a high level of soil contamination in the study area due to the quarrying activities.

- Pollution index of soils in the study area

The pollution index of soils in the area is done using the following index;

Contamination factor (Cf)

Contamination factor (Cf) determines the contamination of a given toxic substance in a basin and it is defines as the ratio of the concentration of the element in sediment samples (C_e) to the background values for the element (C_b).

$$Cf = C_e/C_b \quad (1)$$

Table 3: Classification of Contamination Factor [6]

Class	Cf	Description
1	<1	Low Cf
2	1<Cf<3	Moderate Cf
3	3<Cf<6	Considerable Cf
4	Cf<6	Very high Cf

Geo-accumulation index (Igeo)

Geo-accumulation index defines the metal contamination in sediments by comparing the current concentrations of the sediments with pre-industrial levels [7].

$$Igeo = \log_2 (Cn/1.5 \times Bn) \quad (2)$$

Where Cn = Concentration of the heavy metal and Bn = Background of the heavy metal.

Table 4: Classification of Geo-accumulation Index [7]

Classification	Sediment contamination
< 0	Unpolluted
0 – 1	Unpolluted to moderately polluted
1 – 2	Moderately polluted
2 – 3	Moderately to strongly polluted
3 – 4	Strongly polluted
4 – 5	Strongly to extremely polluted
> 5	Extremely polluted

Enrichment factor (Ef).

Enrichment factor determines the degree of anthropogenic heavy metal contamination of an environment, and this is done by normalizes the trace element content with respect to a sample reference metal (either Fe or Al).

$$Ef = (M/Fe)_{sediment}/(M/Fe)_{background} \quad (3)$$

Where $(M/Fe)_{sediment}$ is the ratio of each heavy metal to iron concentration, while $(M/Fe)_{background}$ is the ratio of the background heavy metal to the background concentration of iron.

Table 5: Classification of Enrichment Factor Index [8]

Classification	Sediment contamination
≤ 2	Low enrichment
2 – 5	Moderate enrichment
5 – 20	High enrichment
20 – 40	Very high enrichment
> 40	Extremely enrichment

Degree of contamination index

The degree of contamination (C_d) is defined as the sum of all contamination factors of the various heavy metals divided by the number of analyzed elements.

Table 6: Classification of Degree of Contamination Index [9]

Class	Cd	Sediment contamination
1K	Cd<1.5	Very low
2	1.5<Cd<2	Low
3	2<Cd<4	Moderate
4	4<Cd<8	High
5	8<Cd<16	Very high
6	16<Cd<32	Extremely high
7	32<Cd	Ultra high

Pollution load index (PLI).

Pollution load index (PLI) is an index for evaluation of contamination status of sediment samples to heavy metals.

$$PLI = (Cf_1 \times Cf_2 \times Cf_3 + \ldots\ldots \times Cf_n)^{1/n} \quad (4)$$

Where Cf is the contamination factor and n is the number of metals.

- Soil contamination index

1. Contamination factor (Cf)

The Contamination factor (Cf) of Fe in the soils from the study area has an index of 1.71 in soils from the factories in the study area, 1.58 in soils by the quarries, 1.32 in soils close to the stream, and 1.23 in soils near hand-dug wells. The soils in the study area have a

moderate contamination factor for iron. The Cf of Mn in the soils at the factories is 1.39, at the quarries is 1.15, at the stream is 1.55 and close to hang-dug wells is 1.12. The soils in the study area have a moderate contamination factor for Mn. The Cf of Zn in the soils at the factories has an index of 1.11, at the quarries an index of 1.06, at the stream an index of 1.23 and close to hang-dug wells an index of 0.90. The soils around the factories quarries and streams in study area have a moderate contamination factor for Zn, while those around the hand-dug wells have a low contamination factor for Zn. The Cf of Cu in the soils at the factories has an index of 1.08, at the quarries an index of 1.00, at the stream an index of 1.00 and close to hang-dug wells an index of 1.09. The soils in study area have a moderate contamination factor for Cu. The Cf of Cd in the soils at the factories has an index of 1.99, at the quarries an index of 1.99, at the stream an index of 1.98 and close to hang-dug wells an index of 2.19. The soils in study area have a moderate contamination factor for Cd. The Cf of Ni in the soils at the factories has an index of 3.09, at the quarries an index of 2.27, at the stream an index of 2.48 and close to hang-dug wells an index of 2.84. The soils in study area have a moderate contamination factor for Ni, with the exemption of those around the factories which has a considerable contamination factor for Ni. The Cf of Pb in the soils at the factories has an index of 1.40, at the quarries an index of 1.13, at the stream an index of 1.88 and close to hang-dug wells an index of 0.92. The soils around the factories quarries and streams in study area have a moderate contamination factor for Pb, while that around the hand-dug wells has a low contamination factor for Pb. The Cf of As in the soils at the factories has an index of 2.08, at the quarries an index of 2.17, at the stream an index of 1.40 and close to hang-dug wells an index of 3.06. The soils around the factories, quarries and streams in study area have a moderate contamination factor for As, while those around the hand-dug wells has a considerable contamination factor for As.

2. Geo-accumulation index (Igeo)

The geo-accumulation index (Igeo) of Fe in the soils from the study area has an index of 0.19 in soils close to the factories, 0.08 in soils at the quarries, -0.19 in soils by the streams and -0.29 in soils around the hand-dug wells in the study area. The soils in the study area around the factories and quarries has an unpolluted to moderately polluted geo-accumulation index for Fe, while those around the streams and hand-dug wells has an unpolluted geo-accumulation index for Fe.

The Igeo of Mn in the soils from the study area has an index of -0.11 in soils close to the factories, -0.38 in soils at the quarries, 0.05 in soils by the streams and -0.42 in soils around the hand-dug wells in the study area. The soils in the study area around the factories, quarries and hand-dug well has an unpolluted geo-accumulation index for Mn, while those around the streams has an unpolluted to moderately polluted geo-accumulation index for Mn. The Igeo of Zn in the soils from the study area has an index of -0.44 in soils close to the factories, -0.50 in soils at the quarries, -0.29 in soils by the streams and -0.73 in soils around the hand-dug wells in the study area. The soils in the study area have an unpolluted geo-accumulation index for Zn. The Igeo of Cu in the soils from the study area has an index of -0.47 in soils close to the factories, -0.58 in soils at the quarries, -0.59 in soils by the streams and -0.47 in soils around the hand-dug wells in the study area. The soils in the study area have an unpolluted geo-accumulation index for Cu.

The Igeo of Cd in the soils from the study area has an index of 0.41 in soils close to the factories, 0.41 in soils at the quarries, 0.40 in soils by the streams and 0.55 in soils around the hand-dug wells in the study area. The soils in the study area have an unpolluted to moderately polluted geo-accumulation index for Cd. The Igeo of Ni in the soils from the study area has an index of 1.04 in soils close to the factories, 0.60 in soils at the quarries, 0.73 in soils by the streams and 0.92 in soils around the hand-dug wells in the study area. The soils in the study area have an unpolluted to moderately polluted geo-accumulation index for Ni. The Igeo of Pb in the soils from the study area has an index of -0.10 in soils close to the factories, -0.41 in soils at the quarries, -0.34 in soils by the streams and -0.70 in soils around the hand-dug wells in the study area. The soils in the study area have an unpolluted geo-accumulation index for Pb. The Igeo of As in the soils from the study area has an index of 0.47 in soils close to the factories, 0.53 in soils at the quarries, -0.10 in soils by the streams and 1.03 in soils around the hand-dug wells in the study area. The soils in the study area around the factories, quarries and hand-dug well has an unpolluted geo-accumulation index for As,

while those around the streams has an unpolluted to moderately polluted geo-accumulation index for As.

3. Enrichment factor (Ef)

The Enrichment factor (Ef) of Fe in the soils from the study area has an index of 1.71 in soils from the factories in the study area, 1.58 in soils by the quarries, 1.32 in soils close to the stream, and 1.23 in soils near hand-dug wells. The soils in the study area have a low enrichment factor for iron. The Ef of Mn in the soils at the factories is 1.39, at the quarries is 1.15, at the stream is 1.55 and close to hang-dug wells is 1.12. The soils in the study area have a low enrichment factor for Mn. The Ef of Zn in the soils at the factories has an index of 1.11, at the quarries an index of 1.06, at the stream an index of 1.23 and close to hang-dug wells an index of 0.90. The soils in study area have a low enrichment factor for Zn. The Ef of Cu in the soils at the factories has an index of 1.08, at the quarries an index of 1.00, at the stream an index of 1.00 and close to hang-dug wells an index of 1.09. The soils in study area have a low enrichment factor for Cu. The Ef of Cd in the soils at the factories has an index of 1.99, at the quarries an index of 1.99, at the stream an index of 1.98 and close to hang-dug wells an index of 2.20. The soils in study area around the hand-dug wells have a moderate enrichment factor for Cd, while soils at the factories, quarries and streams from the study area have a low enrichment factor for Cd. The Ef of Ni in the soils at the factories has an index of 3.09, at the quarries an index of 2.28, at the stream an index of 2.48 and close to hang-dug wells an index of 2.84. The soils in study area have a moderate enrichment factor for Ni. The Ef of Pb in the soils at the factories has an index of 1.40, at the quarries an index of 1.13, at the stream an index of 1.88 and close to hang-dug wells an index of 0.92. The soils in study area have a low enrichment factor for Pb. The Ef of As in the soils at the factories has an index of 2.08, at the quarries an index of 2.17, at the stream an index of 1.40 and close to hang-dug wells an index of 3.06. The soils in study area around the streams have a low enrichment factor for As, while soils at the factories, quarries and hand-dug wells from the study area has a moderate enrichment factor for As.

4. Degree of contamination index (C_d)

The degree of contamination index (C_d) in the soils from the study area has an index of 1.73 in soils from the factories in the study area, 1.54 in soils by the quarries, 1.52 in soils close to the stream, and 1.67 in soils near hand-dug wells. The C_d of the soils in the study area shows that the soils have a low degree of contamination index.

5. Pollution load index (PLI)

The pollution load index (PLI)of the soils from the study area has an index of 1.64 in soils from the factories in the study area, 1.47 in soils by the quarries, 1.46 in soils close to the stream, and 1.49 in soils near hand-dug wells.

CONCLUSION

Quarrying activities being the extraction of solid minerals usually resulted to the release of heavy metals and this usually lead to soil contamination. This is aimed at investigating the geo-environmental impact of quarrying activities on soil in Ikpeshi, Akoko-Edo, Edo State, Nigeria. The study reveals that the contamination factor of iron, manganese, copper and cadmium in the soils from the study area has a moderate contamination factor. The soils around the factories, quarries and streams in study area have a moderate contamination factor for zinc, while those around the hand-dug wells have a low contamination factor. The soils in study area have a moderate contamination factor for Ni, with the exemption of those around the factories which has a considerable contamination factor for Ni, the soils around the factories, quarries and streams in study area have a moderate contamination factor for lead, while that around the hand-dug wells has a low contamination factor. The soils around the factories quarries and streams in study area have a moderate contamination factor for arsenic, while those around the hand-dug wells have a considerable contamination factor. The geo-accumulation index for heavy metals in the soils reveals that the soils in the study area around the factories and quarries has an unpolluted to moderately polluted geo-accumulation index for iron, while those around the streams and hand-dug wells has an unpolluted geo-accumulation index, soils around the factories, quarries and hand-dug well has an unpolluted geo-accumulation index for manganese, while those around the streams has an unpolluted to moderately polluted geo-accumulation index. The soils in the study area have an unpolluted geo-

accumulation index for zinc, copper, lead, and unpolluted to moderately polluted geo-accumulation index for cadmium and nickel. The soils around the factories, quarries and hand-dug well has an unpolluted geo-accumulation index for arsenic, while those around the streams has an unpolluted to moderately polluted geo-accumulation index. The Enrichment factor of iron, manganese, zinc, copper, lead, in the soils from the study area has a low enrichment factor while the soils has a nickel has a moderate enrichment factor for nickel. The soils around the hand-dug wells have a moderate enrichment factor for cadmium, while those around the factories, quarries and streams have a low enrichment factor. The soils in study area around the streams have a low enrichment factor for arsenic, while those around the factories, quarries and hand-dug wells from the study area have a moderate enrichment factor.The degree of contamination index of the soils in the study area shows that the soils have a low degree of contamination index. This research serves as bases for further soil contamination investigation and there is need for constant monitoring of the contamination level of the soil within and around the quarries in the study area.

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